Pilot Study of Softness Presentation by Electro-Tactile Stimulation at the Edge of the Smartphone*

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I. Introduction

In this research, our aim is to devise a novel approach for emulating the tactile perception of softness in materials when interacting with e-commerce websites via smartphones.

While a plethora of investigations have proposed haptic feedback modalities for smartphones, including vibration and friction modulation on the screen, our approach utilizes electrical stimulation to deliver tactile sensations with exceptional spatial resolution [1]. Suga et al. [2] reported that a ring-shaped electrical stimulation pattern correlated with finger indentation can elicit elastic sensation. Based on this, we hypothesized that electrodes placed on the edges of the smartphone, where fingers naturally make contact during grasping, could also evoke the perception of softness.

II. Experiment

Our system comprises of an array of 53 electrodes, positioned along both edges of a smartphone, with a diameter of 2 mm and a center-to-center distance of 3.75 mm. The electrical stimulation employed was anodic in nature, utilizing current pulses with a width of 50 μs and a refresh rate of 60 Hz. Notably, our electrical stimulation device also possesses the capability to detect the contact area by measuring the electrical resistance of the skin through the electrodes.

Suga et al. demonstrated the perception of softness through the application of robust electrical stimulation to the outer edge of the contact area. This approach was informed by the observation that the contact area of the skin tends to increase when interacting with a soft object, owing to its deformable nature. Building upon this principle, we hypothesize that by stimulating the edges of the contact area during a firm grasp of the smartphone, we can elicit the sensation of softness.

This experiment was conducted based on Sheffe's paired comparison method (Ura Variation). The experimental design comprised of three distinct conditions, namely "No stimulation," "Edge stimulation (stimulating the edge of the contact area, Figure 1 Left)," and "Overall stimulation (stimulating the entire contact area, Figure 1 Right)". Participants were tasked with comparing the perceived sensations of softness among the three conditions and selecting one of seven softness comparison options, ranging from "1: A is definitely softer than B" to "7: A is definitely harder than B". Ten participants were recruited (all males, 21-28 years old, M=23.2).

Figure 2 shows the mean scores of the softness evaluation values for each condition. The results unveil that the softness was perceived in the order of overall stimulation, edge stimulation, and no stimulation, in descending order.

The results of ANOVA and post hoc test revealed a significant difference at the 1% level between the no stimulation condition and electrical stimulations. Thus, electrical stimulation enhanced the perception of softness when the smartphone was firmly grasped. However, there was no discernible distinction among the patterns of electrical stimulation. This result could be attributed to the perception of edge stimulation as a weaker variant of overall stimulation. The utilization of a line-shaped electrode array, in contrast to the previous area-based stimulation [2], likely contributed to these unexpected findings.

We received feedback from our experiment indicating that participants perceived a sensation of elasticity akin to that of a rigid sponge. However, a few participants reported perceiving a heightened hardness when exposed to electrical stimulation, describing a numbing sensation that resembled a resistance force, evoking the perception of a harder object.

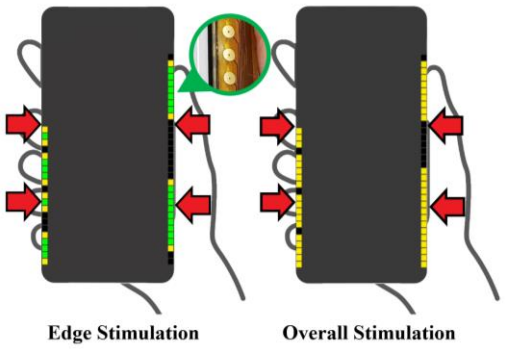

Figure 1. Two types of Electro-tactile stimulations

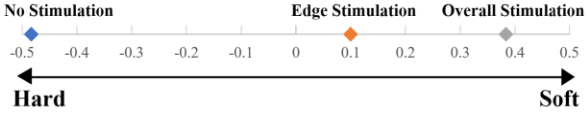

Figure 2. Strength of softness sensation

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